Effect of agent embodiment on the elder user enjoyment of a game

Jérémy Wrobel, Ya-Huei Wu, Hélène Kerhervé, Laila Kamali, Anne-Sophie Rigaud
Broca Hospital
APHP & Team Research EA 4468 of Paris Descartes University Paris, France
Jeremy.wrobel@brc.aphp.fr

Céline Jost, Brigitte Le Pévédic, Dominique Duhaut
Lab-STICC laboratory
University of South Brittany
Vannes, France
and the Robadom Project

***Abstract*— This paper presents a study that compared the elder user enjoyment of a game of trivia in three conditions: participants playing the game with a laptop PC *vs.* a robot *vs.* a virtual agent. Statistical analysis did not show any significant difference of the three devices on user enjoyment while qualitative analysis revealed a preference for the laptop PC condition, followed by the robot and the virtual agent. The elderly participants were concentrated on the task performance rather on the interaction with systems. They preferred laptop PC condition mainly because there were less interfaces distracting them from performing the task proposed by the game. Further, the robot was preferred to a virtual agent because of its physical presence. Some issues of the experiment design are raised and directions for future research are suggested to gain more insight into the effects of agent embodiment on human-agent interaction.**

Keywords: Embodied agent, human-robot interaction, user enjoyment

I. INTRODUCTION

In recent years, one area of interests in human-robot interaction studies is to investigate the physical embodiment effects of social agents on their interaction with humans [1, 2]. A physically embodied robot, with both an actual physical shape, embedded sensors and motors and co-located with a human is considered to facilitate better social interaction by prompting human social expectations for proper social interaction than a disembodied or a virtual agent [1, 3, 4]. Several experiments have been conducted, comparing effects of co-located physical robots with remote or telepresent robots and virtual agents engaging humans in different types of tasks. A variety of objective (e.g. task performance) and subjective measures (e.g. enjoyment) have been used to capture these effects (see table 1 for a review).

Kidd and Breazeal [5] found that a physically embodied robot was considered different than an animated character: it was more engaging, more enjoyable to interact with, and more informative and credible. In another experiment, they showed that participants' perceptions of a physically present robot (co-located with humans) and of a remote one (presented on a television screen) did not differ significantly. As a result, they concluded that what led people to respond differently in the first experiment lies in fact that participants considered both physically present and remote embodied robot as a real and tangible thing, in comparison to the simulated virtual character in the screen. In the studies of Wainer et al. [4, 6], participants rated the physically embodied robot to be more attractive (they spent more time to watch it) and more enjoyable to interact with and more helpful than the virtual robot and the remote robot. Shinozawa et al. [7], showed that a physically embodied robot (three-dimensional body) has more impact on human decision-making when the interaction environment is a three-dimensional space, but has less impact in a two-dimensional space than a virtual on screen robot (two dimensional body). Lee et al. [1] suggested that physical embodiment plays an important role on people's evaluation of social agents even though social agents are not related to any physical function. Furthermore, physical embodiment has an added value for people's social interaction with agents and is an effective means to increase the social presence of an object. Thus, it is an essential aspect of social agents in order to facilitate meaningful social interactions. In the study of Komatsu and Abe [8], most participants accepted the physical robotic agent's invitation to play a game while many neglected the virtual on-screen agent's invitation. The authors suggested that physically embodied robots were considered as more comfortable and believable interactive partners than virtual ones. In the study of Pereira et al. [9], they found that participants who played against the physically embodied agent reported higher enjoyment experiences than those who played with the virtual version of the robot. They suggested that during a computerized chess game, a physical embodied agent elicited a more immersive user experience and a more believable social interaction and led people to believe that they received better system feedback. Hasegawa et al. [10] investigated the impact of embodiment on direction-giving systems by comparing a physically embodied robot, a virtual robot and a GPS. They found that in the direction-giving systems, both physically embodied robot and virtual robot were more positively rated, in comparison to a simple GPS without any embodiment. However, embodied agents did not allow a better cognitive performances (e.g. retelling of direction-giving), comparing with a simple GPS system.

TABLE I. REVIEW OF STUDIES ON EFFECTS OF AGENT EMBODIMENT ON HUMAN-AGENT INTERACTIONS

Authors	**Conditions compared**	**Interaction tasks**	**Measures**
Kidd & Breazeal, 2004	1. Physically embodied robot *vs*. virtual (simulated) robot *vs*. a human 2. Physically embodied robot *vs*. remote robot (presented on TV screen)	1. The participant responded to spoken requests from the characters, which asked the participant to manipulate colored wooden blocks 2. The desert surviving task and a teaching task	1. Questionnaire assessing enjoyment, informativeness, reliability, fairness, credibility, liking, responsiveness, positivity, looking, involvement 2. Questionnaire assessing sincerity, informativeness, dominance, likeability, reliability, openness, trustworthiness, engagement
Shinozawa et al., 2005	2D task environment + no agent *vs*. 2D task environment + virtual robot *vs*. 2D task environment + physical embodied robot *vs*. 3D task environment + no agent *vs*. 3D task environment + virtual robot *vs*. 3D task environment + physical embodied robot	Color-name selection task	The mean selection ratios of the color names that the agent or robot successfully recommended to each subject (influence of agents on decision-making)
Lee et al., 2006	Physically embodied robot (Sony Aibo) *vs*. virtual on-screen robot	Free interaction with robots	Questionnaire assessing perception of Aibo as a companion, social attraction toward Aibo, enjoyment, public evaluation of Aibo, and social presence
Wainer et al., 2006, 2007	Physically embodied robot *vs*. remote robot (presented on TV screen) *vs*. virtual (simulated) robot	Tower of Hanoi puzzle	Task performance, mean time spent in each condition, questionnaire assessing perception of a social agent's capabilities and the user's enjoyment of the task
Komatsu & Abe, 2008	Physically embodied robot *vs*. virtual on-screen robot	Puzzle video game (picross) with agents	Acceptation of the agent's invitation to play a game, duration of looking at the robotic agent, task performance (number of puzzles solved)
Pereira et al., 2008	Physically embodied robot (iCat) *vs*. virtual on-screen robot	Computerized chess game with agents as co-players	Questionnaire assessing user enjoyment in game
Hasegawa et al., 2010	Physically embodied robot with speaker perspective gesture *vs*. physically embodied robot with listener perspective gesture *vs*. physically embodied robot without gesture *vs*. virtual robot with speaker perspective gesture *vs*. virtual robot with listener perspective gesture *vs*. virtual robot without gesture	Listening to systems for a direction-giving	Performance on a retelling of a direction-giving task, performance on a map task and questionnaire assessing naturalness, presence, engagement, understandability, familiarity, reliability and enjoyment

In the current literature review, we did not find any studies investigating human-agent interactions involving elderly subjects who are often targeted as an important population of end-users of social assistive robots and ambient-assisted living technologies. How do they perceive different kinds of agent embodiment? Is there any added value of the physical embodiment of a robot or a virtual agent compared to a simple PC? In the present work, we try to answer these questions by studying interactions between the elderly and the physically embodied robot, a virtual agent and a simple laptop PC in the situation where they played a game of trivia (e.g. geography, history, literature…).

II. Experiment

The design of this study was a within-subjects, repeated measures experiment. Three conditions were set up: subjects interacted with a laptop *vs.* a virtual agent (Greta [11]) *vs.* a physically embodied robot. In each condition, subjects were invited to play a game of trivia StimCards with the system which gave instructions and feedbacks. We compared user enjoyment and engagement within these three conditions.

A. StimCards

StimCards is an interactive card game which is played between a human player and a computing player. The computing player is the game coordinator which asks questions and corrects answers given by the human player. StimCards is composed of:

- A set of game cards with a barcode (a QR code) on the verso. The left side of the figure 1 shows response items and the right side shows the verso with QR code.
- A camera which can detect QR code and load associated questions.
- A computer screen which displays StimCards GUI and the content of questions. Figure 2 shows StimCards GUI with an example of loaded card.
- An associated input device which allows human player answering questions. **Erreur ! Source du renvoi introuvable.** shows the input device provided to human player during the experiment.

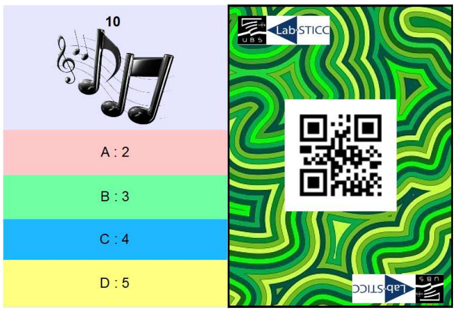

Figure 1. StimCards game example

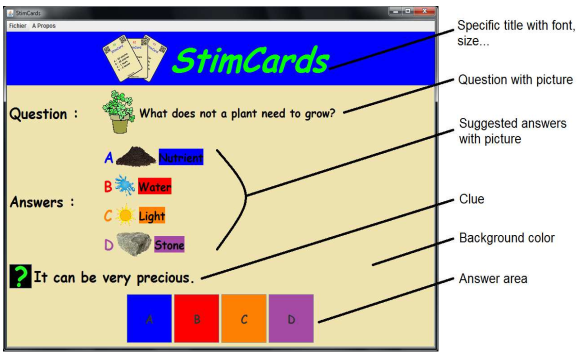

Figure 2. A loaded card in StimCards GUI

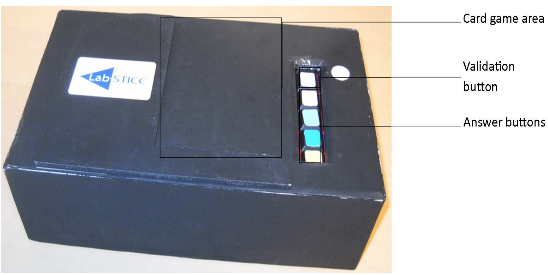

Figure 3. Response box

Each card is associated to a XML file which contains: the question label and associated picture, question type (multiple choice question, open question …), a card category (entertainment, sciences, math…), GUI background color, font color, a set of clues which can help gamers, a set of suggested answers (text and/or picture) and the correct answer. It is possible to create new questions by changing XML file content or creating new game card associated to new XML file. StimCards is created with MICE [12], a computing modular framework within which a visual programming language creats interaction scenarios allowing digital devices to communicate with each other. Thus, StimCards is configurable in two ways: it is possible to create new cards and to describe the game sequences (interaction scenario).

B. Participants

We recruited nineteen elderly participants with a range in age from 63 to 88 years and with a mean of 75.71 (6.76). There were 3 men and 16 women. They were contacted by phone from an existing study participant recruitment pool. A consent form was signed by all of the participants before partaking in this experiment.

C. Experimental conditions

Participants played a game of trivia with the following devices (Fig 4):

a) Laptop PC: subjects were seated in front of a table containing a laptop PC, a webcam, a response box and the playing cards.

b) Physically embodied robot: subjects were seated in front of a table containing a webcam, a response box and the trivia cards. The robot (Robulab of Robosoft) with a screen was placed at the right side of the table.

c) Virtual agent + PC laptop: subjects were seated in front of a table containing a laptop PC, a webcam, a response box and the trivia cards. The virtual agent (Greta) was projected on the wall at the right side of the table.

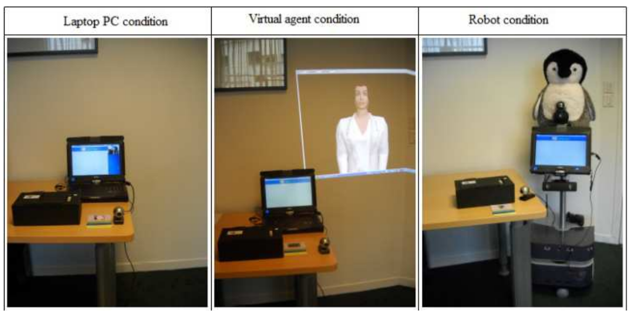

Figure 4. Experimental scene

D. *Task*

In each condition, participants played a game of trivia. The questions of the game were based on general knowledge, composed of 5 themes (literature, cinema, politic, geography, music). For each question, there were 4 possible answers and only one was correct. Each participant was asked to respond to 10 questions.

We created the following scenario for each condition:

1. Device says “Hello. Press the validation button from the response box when you are ready”.
2. Participant player presses the button.
3. Device says “Hello. I will ask you 10 questions. You will use the black response box to put your card and answer the question. Exercises start now.”
4. Device says “You can scan a card by placing it in front of the camera”.
5. Participant shows a card to the camera.
6. Device says “A card has been detected. Put your card on the response box and press the validation button when you are ready”.
7. Participant presses the validation button.
8. Device reads the question while the computer screen displays the question content of StimCards.
9. Participant responds to the question.
10. If participant responds correctly, device says “Congratulation! It is the good answer. ». If the participant gave the wrong answer, device said “Sorry, it is not a good answer. The good answer is […]”.
11. The step 4-10 are repeated nine times. At the end, device says “Exercises are finished. Thank you for your participation”.

E. *Procedure*

Upon arriving at the living lab (Hôpital La Collégiale, Paris), subjects were told the purpose of the experiment. If they agreed to participate, they signed a consent form. In a randomly assigned order, each subject performed the task in three conditions. In each condition, the subject filled out a questionnaire assessing user enjoyment. At the end of the three conditions, they were asked to comment on the three systems and to talk about the system they preferred to interact with.

F. *Measures*

To evaluate user enjoyment and engagement, we designed a questionnaire that consisted of items based on GameFlow model [13] and United Theory of Acceptance and Use of Technology (UTAUT) [14].

The 5-point Likert questionnaire consisted of 13 items (Table II), measuring four dimensions of GameFlow (*feedback, immersion, social interaction, concentration*) and 2 dimensions of UTAUT (*intention to use, perceived enjoyment*). Participants were asked to indicate their level of agreement to the statement following the 5-point response scale anchored by “not agree” and “Totally agree”. Moreover, observation and note taking were carried out for qualitative analysis.

III. RESULTS

A one-way within-subjects ANOVA was conducted to compare user enjoyment in the three conditions. In total, 19 subjects took part of the experiment. Because of technical problems, we did not take two participant evaluations into account. The Table III shows the means, standard deviations and analysis of variance of the global score and sub-scores of user enjoyment in the three conditions. Even though subjects rated higher user enjoyment under the laptop PC condition, compared to the two other conditions, the results of ANOVA did not show any significant differences among the three conditions.

We have performed a qualitative analysis from observation and field notes about how participants interacted with systems and how they considered of them during the experiment. We observed that a majority of the participants were concentrated on the response box and they rarely looked at the screen of the laptop PC, the robot and the virtual agent. In fact, they looked at these devices at the beginning but after a few minutes, they concentrated on manipulating the response box to perform the task.

TABLE II USED QUESTIONNAIRE

Domains	Statements
Concentration	• I was caught up in the game. • I stayed focused on the game.
Immersion	• I felt involved in the game. • I forgot about time passing while playing the game.
Social interaction	• I found that interaction with the […] was pleasant. • I appreciated accompanied by the […]. • Playing condition was convivial.
Feedback	• I received immediate feedback on my actions. • I appreciated the feedback given by the […].
Intention to use	• I would recommend this game to people around me. • If the multiplayer mode exists, I would recommend playing this game with my friends.
Perceived enjoyment	• Generally, I enjoyed playing the game. • Alone, I would accept to play the game with the […].

TABLE III. MEANS, STANDARD DEVIATIONS AND ANALYSES OF VARIANCE OF THE GLOBAL SCORE AND SUB-SCORES OF USER ENJOYMENT IN THE THREE EXPERIMENTAL CONDITIONS

	Laptop	Robot + laptop pc	Virtual agent + laptop pc	*F*(2,48)	*p*
Global score	44.29 (8.39)	41.76 (9.75)	40.12 (9.27)	1.02	0.37
Feedback	3.44 (0.73)	3.41 (0.76)	3.24 (0.94)	0.32	0.73
Immersion	3.44 (0.83)	3.24 (0.95)	3.08 (0.95)	0.75	0.48
Social interaction	3.67 (0.53)	3.18 (0.96)	2.94 (1.18)	2.70	0.08
Concentration	3.56 (0.63)	3.32 (0.92)	3.47 (0.74)	0.40	0.67
Intention to use	3.15 (1.17)	2.88 (1.33)	2.85 (1.30)	0.28	0.76
Perceived enjoyment	3.18 (0.98)	3.26 (1.00)	3.03 (0.96)	0.25	0.78

Further, most of participants reported that they preferred the laptop PC condition to the other conditions because they could be more concentrated on the task. On the other hand, they considered the devices for two other conditions too cumbersome and not easy to use. They did not see any added value of virtual agent and robot when performing the task. For the condition of the robot, some participants appreciated the robot's physical presence compared to the virtual agent. Nevertheless, they judged the robot's head, a stuffed animal, too childish. Furthermore, they found it lacking life-like characteristics. As for the virtual agent + PC laptop condition, only a few subjects appreciated the presence of the virtual agent. Most of the participants criticized it because they found it adynamic and its gaze lacking emotion.

IV. DISCUSSION

This study investigated user enjoyment in a game of trivia in three conditions: laptop PC *vs.* robot *vs.* virtual agent. Although participants rated higher user enjoyment under the laptop PC condition, followed by the robot condition and the virtual agent condition, statistical analysis did not show any significantly difference among the three conditions (fig.6).

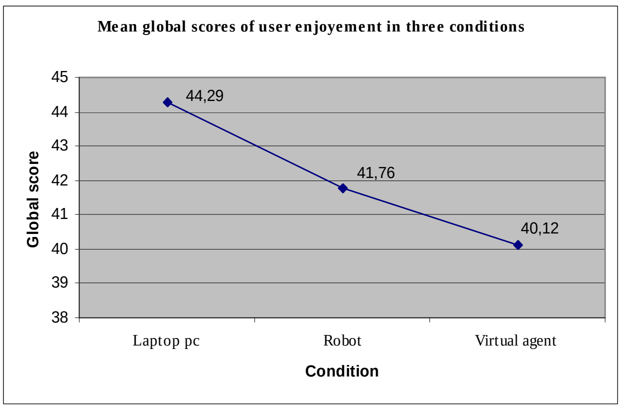

Figure 6. Mean global scores of user enjoyment in three conditions

The preference towards the laptop PC condition can be explained by the fact that participants were mainly concentrated on the task performance rather than one "social interaction" with the system. They focused on the response box and rarely looked at the other interfaces except for the PC screen. Some of them even considered that the robot and the virtual agent distracted them from performing the task. Furthermore, several participants reported that there were too many things to look at and they could not pay attention to all interfaces. This result is somehow not surprising as impairments in divided attention and associated executive functions are dominant among the cognitive impairments associated with normal aging [15]. Besides, many subjects conceded that they did not see any added values of a robot or a virtual agent in this kind of task. They said that they did not find it interesting to play with a robot or a virtual agent partly because they lack living characteristics and their appearance is not appealing.

On the other hand, our findings also showed that the participants preferred the robot condition compared to the virtual agent condition. According to our qualitative analysis, the advantage of a robot over a virtual agent is that a robot provides a physical presence. For example, some participants said that the robot was tangible and they could touch it. This result is similar to other studies investigating the effects of agent embodiment on human-agent interaction. Lee et al. [1] suggested that a physically embodied agent may facilitate better social interaction with its users by providing more affordance for proper social interaction than a disembodied agent. In the same line, Kidd and Breazeal [5] indicated that the fact that people consider robots as "real entities" might facilitate face to face interaction.

V. CONCLUSION

In the current experimental setup, participants did not report any perceived added values of a robot and a virtual agent in comparison to a simple laptop PC in a specific interaction situation. This finding can be explained by the fact that in this experiment, the robot and the virtual agent lacked living characteristics and that the task required participants to focus on task performance rather on their interaction with systems. Future studies should address the issue of agent design and use different kinds of tasks to gain insight into the effects of agent embodiment on human-agent interaction.

Furthermore, in a future experiment, we should reduce or simplify interfaces of interaction systems because of divided attention difficulties in older adults. Finally, our findings are in line with those of previous studies, showing people prefer the physical embodiment of a robot rather than a projected bust of a virtual agent in an interaction situation.

ACKNOWLEDGMENT

This study has been supported by the French National Research Agency (ANR) through the TECSAN programme (ANR-09-TECS-012) and the CNSA (Caisse nationale de solidarité pour l'autonomie).

REFERENCES

[1] K. M. Lee, Y. Jung, J. Kim, and S. R. Kim, "Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human-robot interaction," *International journal of human-computer studies,* vol. 64, pp. 962-973, 2006.

[2] K. Dautenhahn, "I could be You: The Phenomenological Dimension of Social Understanding," *Cybernetics and Systems: An International Journal,* vol. 28, pp. 417-453, 1997.

[3] T. Fong, I. Nourbakhsh, and K. Dautenhahn, "A survey of socially interactive robots," *Robotics and Autonomous Systems,* vol. 42, pp. 143-166, 2003.

[4] J. Wainer, D. J. Feil-Seifer, D. A. Shell, and M. J. Mataric, "The role of physical embodiment in human-robot interaction," in *IEEE Proceedings of the International Workshop on Robot and Human Interactive Communication*, 2006, pp. 117-122.

[5] C. D. Kidd and C. Breazeal, "Effect of a robot on user perceptions," in *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2004, pp. 3559-3564.

[6] J. Wainer, D. J. Feil-Seifer, D. A. Shell, and M. J. Mataric, "Embodiment and human-robot interaction: A task-based perspective," in *16th IEEE International Conference on Robot & Human Interactive Communication*, 2007, pp. 872-877.

[7] K. Shinozawa, F. Naya, J. Yamato, and K. Kogure, "Differences in effect of robot and screen agent recommendations on human decision-making," *International journal of human-computer studies,* vol. 62, pp. 267-279, 2005.

[8] T. Komatsu and Y. Abe, "Comparing an On-Screen Agent with a Robotic Agent in Non-Face-to-Face Interactions Intelligent Virtual Agents." vol. 5208, H. Prendinger, *et al.*, Eds., ed: Springer Berlin / Heidelberg, 2008, pp. 498-504.

[9] A. Pereira, C. Martinho, I. Leite, and A. Paiva, "iCat, the chess player: the influence of embodiment in the enjoyment of a game," in *The 7th international joint conference on Autonomous agents and multiagent systems*, 2008, pp. 1253-1256.

[10] D. Hasegawa, J. Cassell, and K. Araki, "The role of embodiment and perspective in direction-giving systems," in *Dialog with robots: AAAI Fall Symposium*, 2010.

[11] S. Pasquariello and C. Pelachaud, " "Greta : A Simple Facial Animation Engine"," in *6th Online World Conference on Soft Computing in Industrial Applications*, 2001.

[12] C. Jost, B. Le Pévédic, and D. Duhaut, "Creating Interaction Scenarios with a New Graphical User Interface," in *International Workshop on Intelligent Interfaces for Human Computer Interaction*, Palermo, Italy, 2012, pp. 531-538.

[13] P. Sweetser and P. Wyeth, "GameFlow: a model for evaluating player enjoyment in games," *Computers in Entertainment*, vol. 3, pp. 3-3, 2005.

[14] M. Heerink, B. Kröse, V. Evers, and B. Wielinga, "Assessing Acceptance of Assistive Social Agent Technology by Older Adults: the Almere Model," *International Journal of Social Robotics,* vol. 2, pp. 361-375, 2010.

[15] M. Sarter and J. Turchi, "Age-and dementia-associated impairments in divided attention: psychological constructs, animal models, and underlying neuronal mechanisms," *Dementia and geriatric cognitive disorders,* vol. 13, pp. 46-58, 2002.